

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing this collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0188), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number. PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.

1. REPORT DATE (DD-MM-YYYY)	2. REPORT TYPE	3. DATES COVERED (From - To)		
	Technical Papers			
4. TITLE AND SUBTITLE		5a. CONTRACT NUMBER		
<p>Please see attached</p>		5b. GRANT NUMBER		
		5c. PROGRAM ELEMENT NUMBER		
		5d. PROJECT NUMBER 1011		
		5e. TASK NUMBER 0046		
		5f. WORK UNIT NUMBER 346204		
				8. PERFORMING ORGANIZATION REPORT
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)		9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)		
Air Force Research Laboratory (AFMC) AFRL/PRS 5 Pollux Drive Edwards AFB CA 93524-7048		10. SPONSOR/MONITOR'S ACRONYM(S)		
		11. SPONSOR/MONITOR'S NUMBER(S)		
		Please see attached		
12. DISTRIBUTION / AVAILABILITY STATEMENT				
Approved for public release; distribution unlimited.				
13. SUPPLEMENTARY NOTES				
14. ABSTRACT				
<p style="text-align: right;">20030121 096</p>				
15. SUBJECT TERMS				
16. SECURITY CLASSIFICATION OF:		17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
		<p style="text-align: center;">A</p>	19b. TELEPHONE NUMBER (include area code) (661) 275-5015	Leilani Richardson
a. REPORT	b. ABSTRACT			c. THIS PAGE
Unclassified	Unclassified	Unclassified		

TP-FY99-0102
ERC # E99-015

✓ Spreadsheet
✓ DTS

MEMORANDUM FOR PRR (Contractor/In-House Publication)

FROM: PROI (TI) (STINFO)

4 June 1999

SUBJECT: Authorization for Release of Technical Information, Control Number: AFRL-PR-ED-TP-FY99-0102
Brand, Hawkins..., "Laboratory Characterization of High Energy Materials"

HEDM Poster Session

(Public Release)



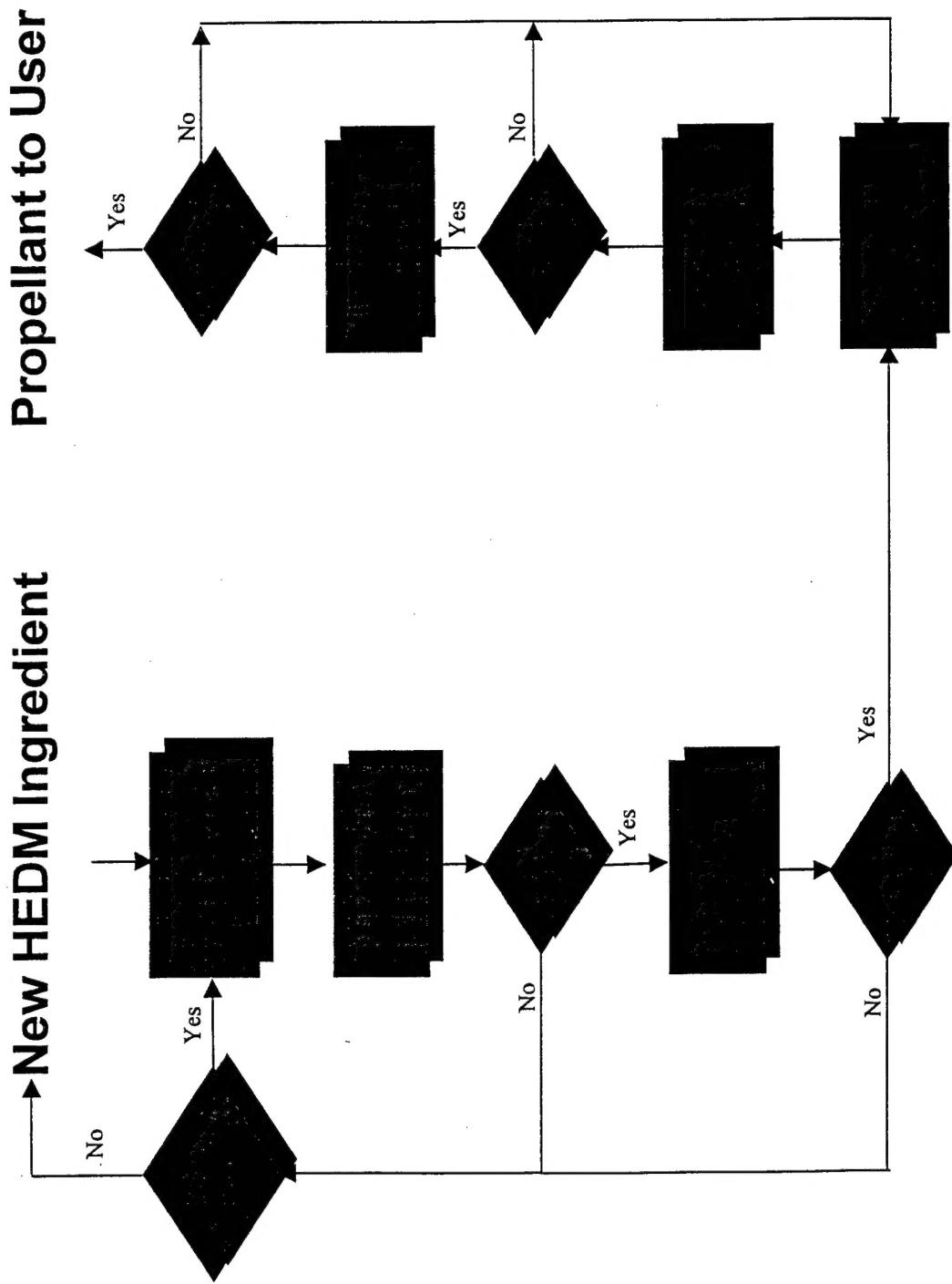
Laboratory Characterization of High Energy Materials

A.J. Brand, T.W. Hawkins, and M.B. McKay
AFRL, Edwards AFB, CA
I.M.K. Ismail
ERC Inc., Edwards AFB CA

AFOSR HEDM Conference
10 June 1999

Approved for public release; distribution unlimited.

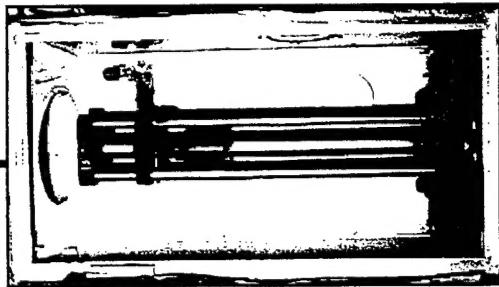
Approach to Advanced Propellant Development



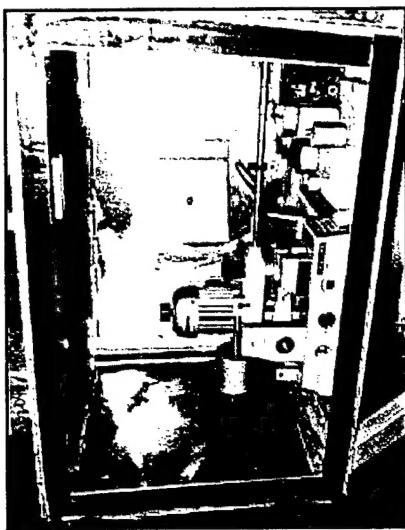
Ingredient/Propellant Testing



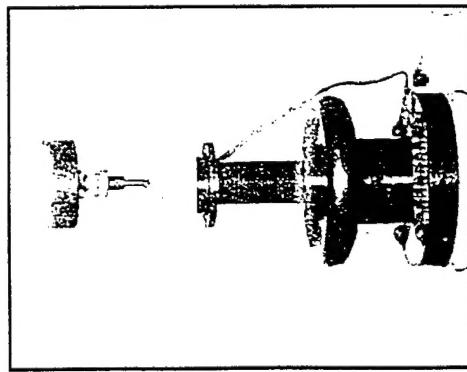
Impact



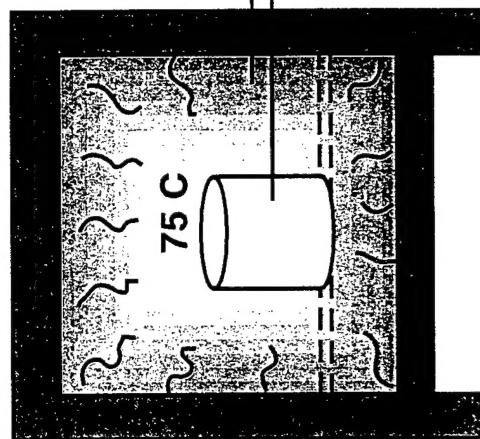
Friction



Electrostatic Discharge



Thermal



48 Hours

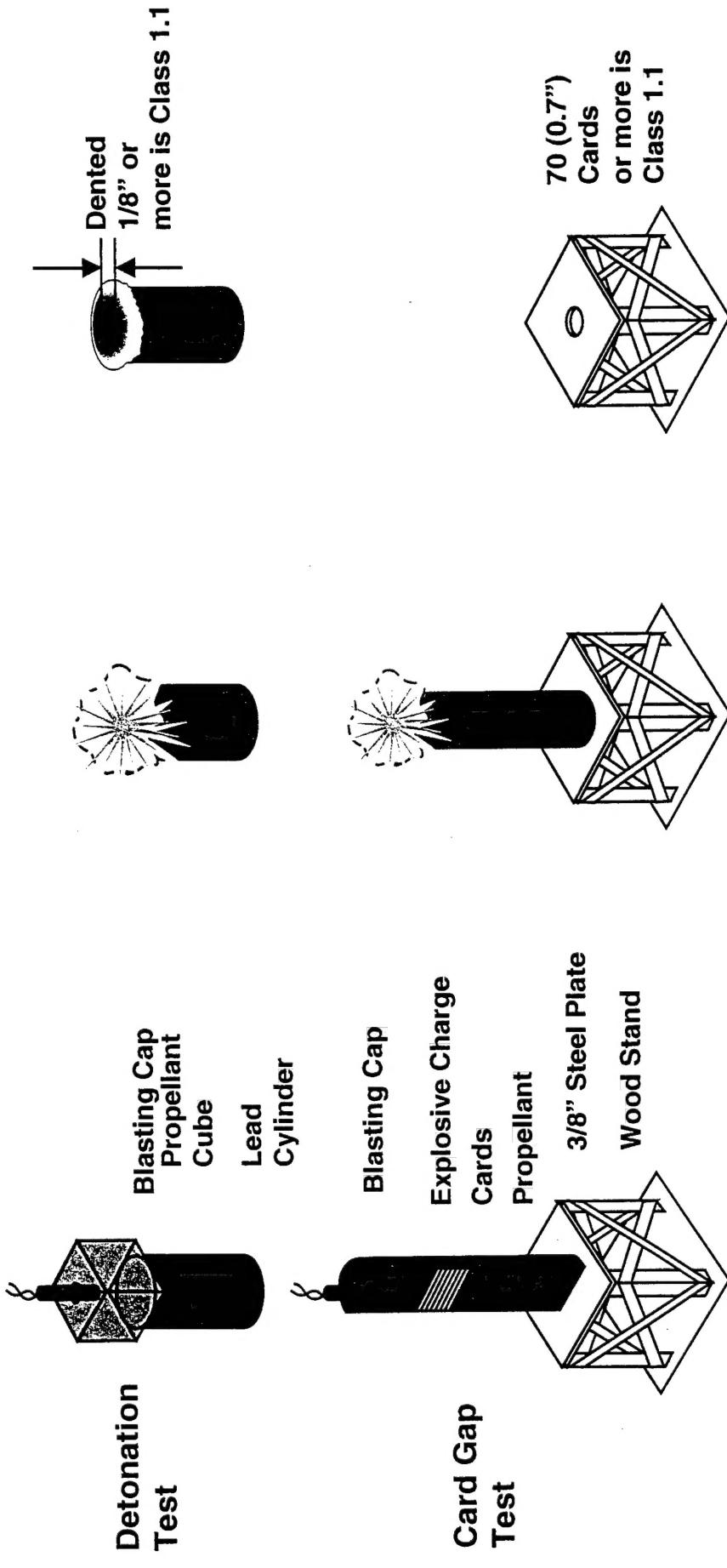
$\Delta T < 3^\circ\text{C}$
 $\Delta W > 2\%$



Ingredient/Propellant Testing

Shock to Detonation Tests

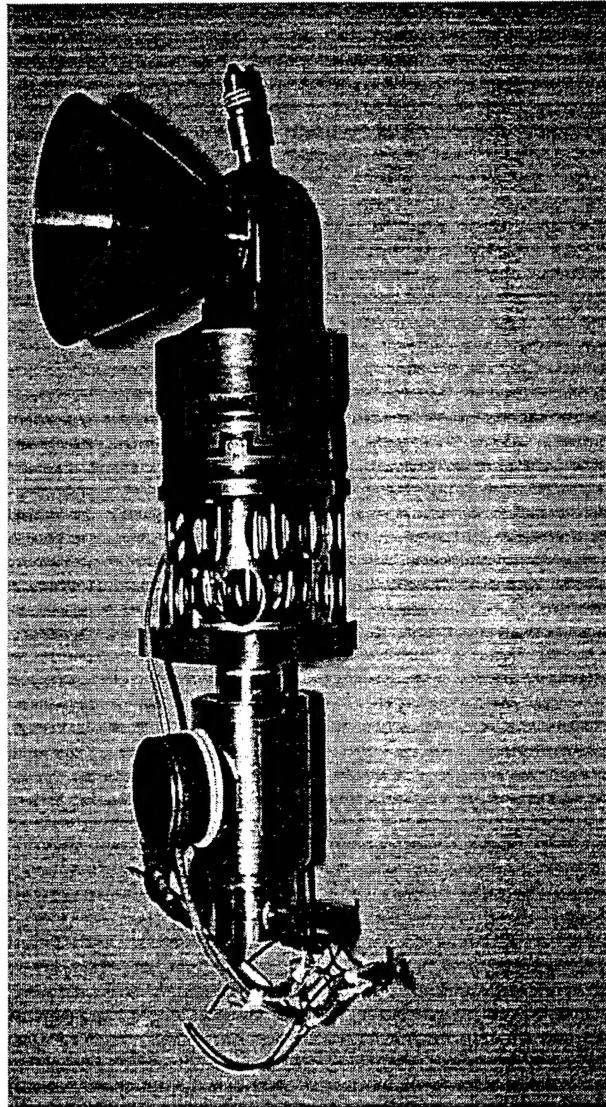
- All current solid rocket propellants are divided into two hazard classifications (1.1 or 1.3)
- Two tests are used to distinguish between Classes 1.1 and 1.3





Candidate Salt Ingredient Characterization & Safety Testing

Amine Functional Nitrate (AFN)



- AFN is a Dense, Low Melting Liquid Salt Suitable as a Monopropellant Ingredient
- AFN Meets Thermal Stability, ESD, Impact, Friction, and Detonability Requirements to Continue Development

Acceptable Monopropellant Properties



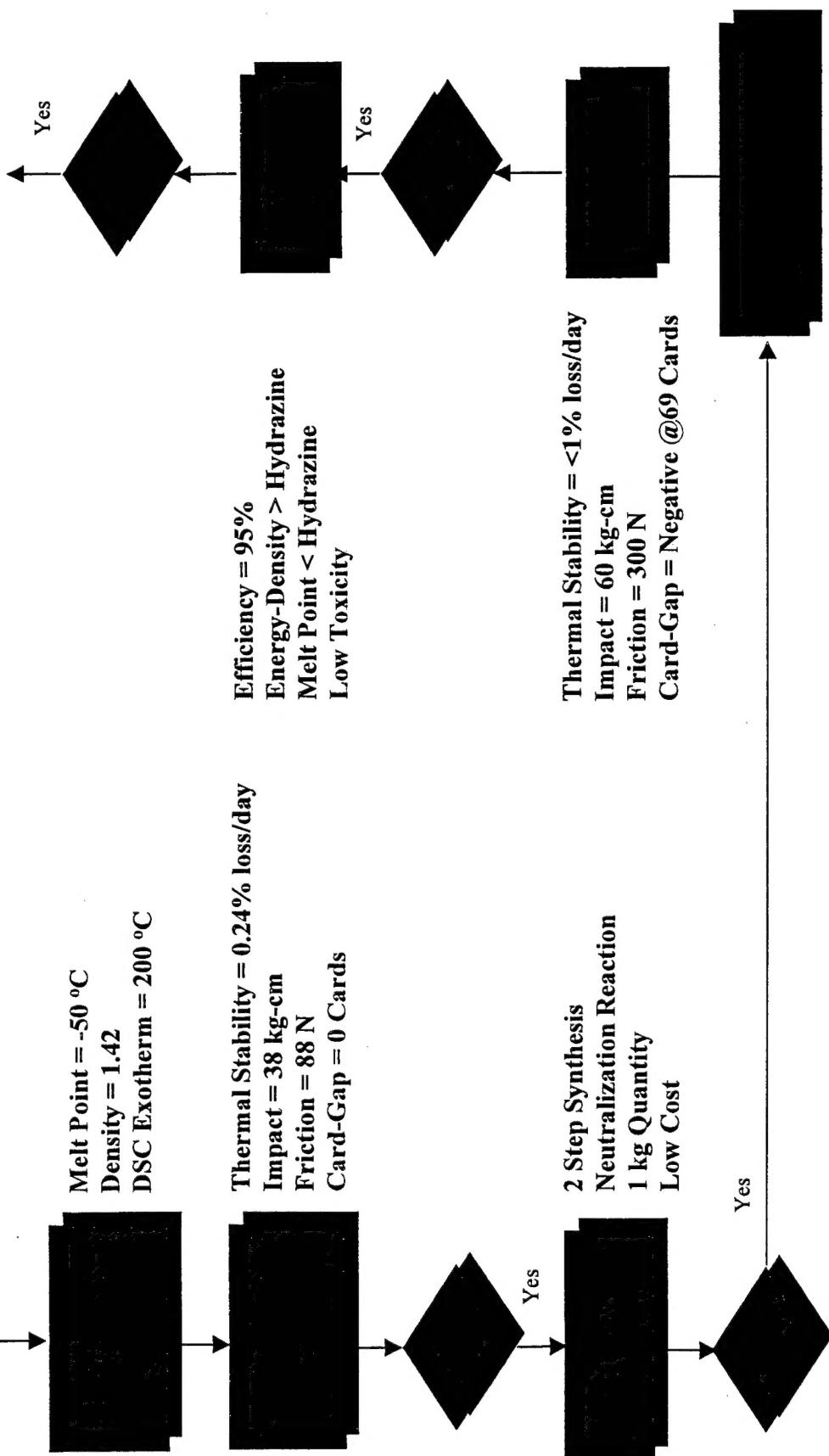
Characteristic	Objective
Density Isp [300 psi-vac; exp=50]	> 50% increase over Hydrazine
Vapor Toxicity	Does Not Exceed TLV (No SCBA in Handling)
Carbon Content	No Solid Carbon Forms in Theoretical Exhaust
Melting Point	< 2°C
Detonability [NOL Card Gap]	Class 1.3; (Prefer 24 Cards Maximum (E ₅₀))
Impact Sensitivity [Drop Weight]	20 kg-cm Minimum (E ₅₀)
Adiabatic Compression [U-Tube Test]	No Explosive Decomposition (Pressure Ratio of 35)
Thermal Stability	< 2% by wt. Decomposition for 48 hrs at 75°C
Critical Diameter	No Propagation in Lines of < 0.75 inch Diameter

* Reference: (1) M.B. Frankel et. al., Rocketdyne Div., Rockwell International,
Technical Report, May 1979.



AFN Propellant Development

Propellant Submitted to User AFN





Monopropellant Chemical/Physical Characteristics

Properties	AFN1	AFN2	HAN-Based	Hydrazine
Density, g/cc	1.43	1.46	1.34	1.01
Viscosity, cp	8.6	23.1	7.4	0.97
Chamber Temp. (Theoretical), K	2070	2083	1369	883
Carbon Content of Exhaust; (b)	none	none	none	none
Impact Sensitivity, kg-cm (5 negatives)	>200	60	>200	>200
Friction Sensitivity, N (5 negatives)	318	300	>371	>371
NOL Card Gap (at 69 Cards)	negative	negative	negative	negative
Thermal Stability, %wt loss/48hr,75°C	< 0.5	1.96	5.1%	(< 0.1)
Melt Point, C	5 (c)	<-22	-39	1

a: Theoretical, calculated with 300 psi chamber pressure, exhaust to vacuum, 50/1 expansion

b: as soot or solid carbon (by theoretical computation)

c: by DSC; melt transition was broad, melt peak reported

*: For reference, n-propyl nitrate had an impact sensitivity of 8 kg-cm

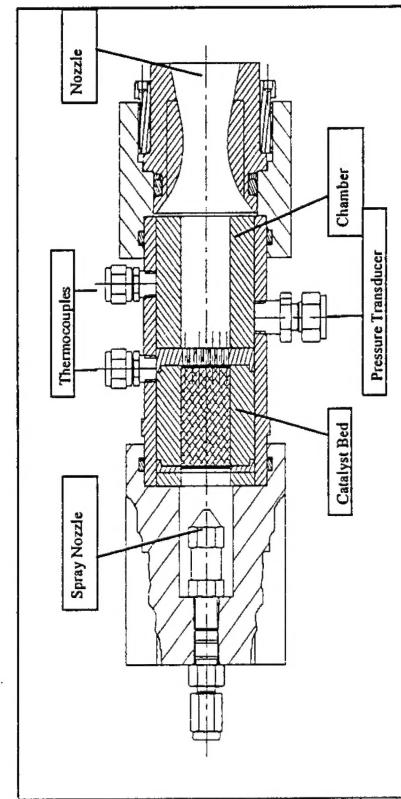
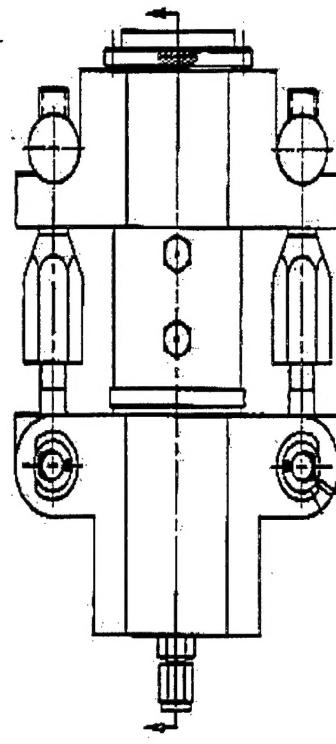
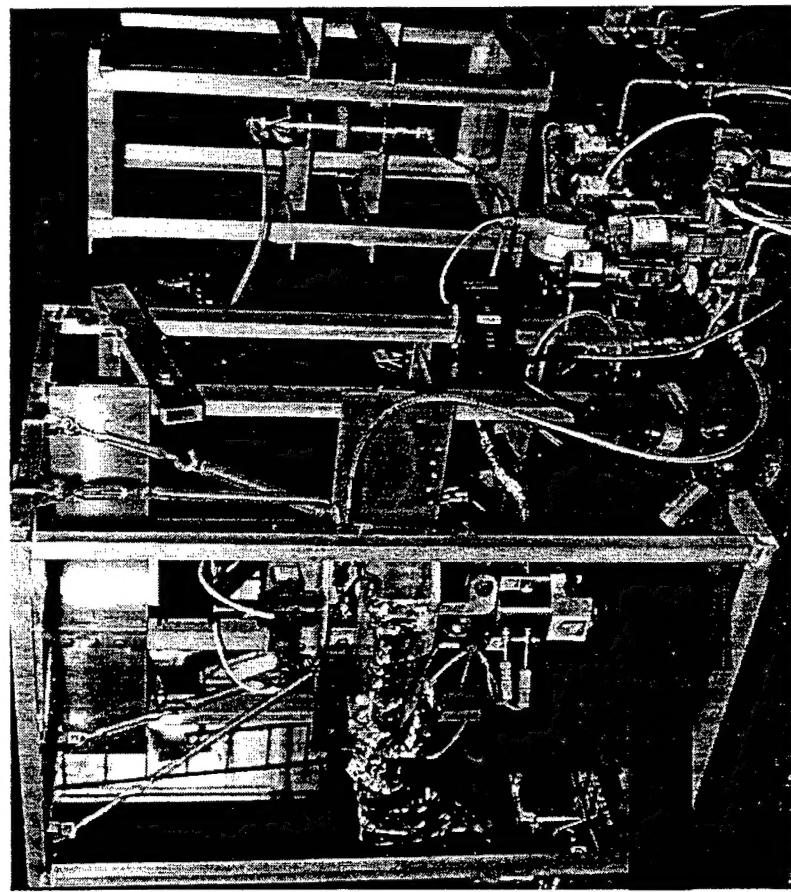
AFN-Based Propellants Display Acceptable Safety/Sensitivity Properties For Continued Development



Monopropellant Thruster Testing

Monopropellant Thrust Stand

15 lbf Modular Thruster



AFRL Fabricated Thruster and Initiated Testing
at National Hover Test Facility in 1998



Monopropellant Thruster Testing

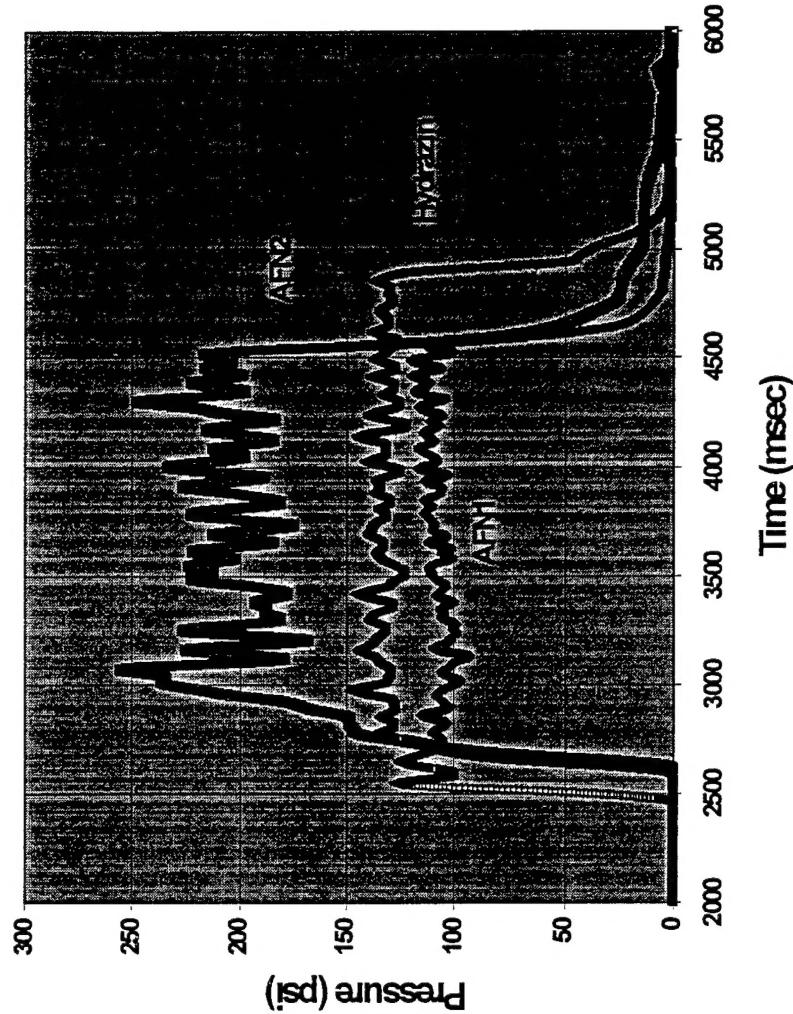
Monopropellant Test Firings

Monoprops %Efficiency

Hydrazine 96

AFN1 85*

AFN2 95



* Compromised Seal
Caused Leaking of
Exhaust and Poor
Performance



Toxicology of AFN

Toxicology

PROPERTY	AFN	HAN (13M)	HYDRAZINE
LD50 (rat), mg/kg	367	325	60
Dermal Irritation	Slight	Moderate	Corrosive
Genotoxicity (Ames)	3 Negative/ 2 Positive	Negative	Positive

Vapor Toxicity (TVDL)

AFN no detection <1 ppb (TLV for Hydrazine is 0.01 ppm)

AFN Evaluation:

- Negligible Vapor Pressure
- 6X Less Oral Toxicity than Hydrazine
- Very Low Dermal Irritation
- Genotoxicity (Bacterial) in 2 of 5 Strains



Laboratory Characterization of High Energy Materials

Conclusions

- AFN Has Demonstrated Acceptable Properties to Further Propellant Development
 - Displayed Good Stability (Thermal, Friction, Impact and Detonability)
 - Low Melt Point is Suitable for Monopropellant Applications
 - Extremely Low Toxic Vapor Concentrations
- AFN-Based Propellant Has Been Evaluated to Indicate Additional Development is Warranted
 - High Performance Demonstrated in Thruster Testbed
 - Acceptable Safety Properties
 - Low Toxic Vapor Concentrations
- Propellant Submitted to Industry for Evaluation